



1216077

October 23, 2000

Title: Design for Constructing an Input Circuit to Receive
and Process an Electrical Signal

Description

The invention relates to a design for constructing an input circuit to receive and process an electrical signal, such as a voltage signal, a voltage source, specifically from a sensor, such as an electrochemical, inductive or optical sensor, where the input circuit has an extremely high input resistance of at least 10^{11} ohms and is located on a printed circuit board, where an first area of the printed circuit board carrying input circuit components is separated from a second area, which surrounds it or is contiguous to it, by a channel-shaped recess.

Specifically the present invention relates to an input circuit for measurement processing equipment to operate a sensor, specifically an electrochemical sensor for measuring pH. The sensor electrodes constitute a voltage source with an internal resistance of up to 1 gigohm. In order to be able to receive and process these voltages and thus measurement signals from the sensor, a suitable input circuit is required which puts such a small load on the voltage source that the error resulting from the reception and processing of the measurement signal is smaller than the acceptable measurement error. Normally an input resistance is required which is than the internal resistance of the electrode array of the sensor higher by a factor of 1000. The input resistance must be at least 10^{11} ohms, preferably be 5×10^{11} ohms and the preference is for 10^{13} ohms and higher.

An input circuit, particularly for recording the measurement signal from a pH-sensitive electrode array, normally comprises a high-resistance operational amplifier, which is wired in the circuit as a buffer (1 amplification) and thus amplifies the measurement signal for further processing of the measurement voltage. If an input circuit of this type is located on conventional printed circuit board material, specifically FR4 material, it operates reliably only under laboratory conditions, because under laboratory conditions (suitable temperature, low relative

humidity) hardly any leakage current is drained off over the base material of the printed circuit board and of its surface and the surface of components involved.

However, if the input circuit is exposed to higher relative humidity and temperature under operating conditions (for example, 60°, 95 percent relative humidity), there is a risk that the reading will be falsified because of current leakage across the lower resistance base material on the circuit card, as a result of penetration of water molecules, as well as from current bridges, for example, across etched-in dirt particles on the surfaces of the input circuit and circuit card components. Without special measures, moisture cannot be prevented from penetrating into the base material of standard circuit cards. Standard circuit cards are constructed on a fiberglass-reinforced epoxy resin base and typically are capable of absorbing moisture. Water molecules can become embedded in the chemical structure of the epoxy resin. Furthermore water molecules can migrate by capillary action to the adjacent surfaces between the epoxy resin and embedded glass fibers into the interior of the printed circuit board.

This problem has been solved until now by the use of ceramic base material (so-called hybrid printed circuit boards) and an encapsulation of the input circuit by means of a high-fill, epoxy-based sealing material. This solution is relatively expensive, however, because of the costly material and is associated with time-intensive manufacturing.

In the applicant's patent DE 198 10 736 A1 a measurement input for a high-resistance input circuit was proposed, where a section of the printed circuit board assigned to the measurement input is isolated from the other areas of the printed circuit board by a dividing gap passing completely across the printed circuit board; this section is connected to an operational amplifier which, however, is not provided on the isolated section of the printed circuit board. It was possible to produce a high-resistance input circuit of this type under DE 198 10 736 A1 economically by assembling the printed circuit board in automated pick-and-place equipment and subsequently creating an insular section as the measurement input for the circuit. Taking this as a point of departure, the object of the present invention is to effectively counteract the effects of moisture on the input circuit.

In addition, as already mentioned at the beginning, the use of a ceramic base material (hybrid printed circuit board) as base material in place of conventional printed circuit board materials (FR4 material) and locating the components of the input circuit on it was already known. By encapsulating the input circuit with a high-fill, epoxy-based sealant it was possible to obtain the requisite input resistances on the input circuit. However, as already mentioned, this solution is expensive and time-intensive in production.

In contrast, the object was to bring about more economical manufacturability

The preceding aspects of the object are met under the invention in a high-resistance input circuit of the generic type by having the channel-shaped recess in the interior of the printed circuit board stop, at least in sections not form a dividing gap passing completely through the printed circuit board, as in DE 198 10 736 A1, and extend directly in the direction of its thickness as far as a moisture-impermeable barrier layer (diffusion dam) which underlies the first area of the printed circuit board and by having the channel-shaped recess and the first area filled and enclosed by a cohesive moisture-impermeable sealing material.

The high-resistance components of the input circuit are therefore placed on the first area, which is made of conventional printed circuit board material, specifically FR-4 printed circuit board material, and overlaid by the moisture-impermeable sealing material. This first printed circuit board area is closed and sealed in a moisture-tight manner to the bottom and to the inside, specifically by the moisture-impermeable barrier layer on one side and laterally by the sealing material which fills the circumferential channel-shaped recess. As a result of the circumferential channel-shaped recess being extended right up to the moisture-impermeable barrier layer, complete sealing of the first printed circuit board area against moisture is achieved. So if any moisture which has found its way into the printed circuit board material penetrates from the inside in the direction of the first area on which the input circuit is located, the moisture is prevented from progressing to the circuit components by the moisture-impermeable barrier layer and by the sealing material filling the channel-shaped recess. The moisture-impermeable barrier

coat can be achieved or configured in any way as long as effective blocking action against penetrating moisture is obtained. It has proved to be effective if the moisture-impermeable barrier layer is formed by a metallic layer inside the printed circuit board. This metallic layer is preferably flat, it extends continuously under the first area, that is without any breaks. The primary material of the printed circuit board can be a copper-clad printed circuit board, specifically a multi-layer printed circuit board. With respect to economical manufacturability of the printed circuit board, it proves to be advantageous if it is made from conventional FR-4 material, which has at least one moisture-impermeable barrier layer on the inside.

It has furthermore proved to be quite particularly advantageous if the walls of the printed circuit board adjacent to the channel-shaped recess have been furnished on their part with a moisture-impermeable coating, specifically in the form of a metal plating prior to pouring in the sealing material. This moisture-impervious coating is then in direct contact with the moisture-impervious barrier layer which underlies the first area of the printed circuit board and seals it against moisture. The moisture-impervious sealing material is produced on an epoxy base or on a high-density polyethylene or liquid resin base.

Additional features, details and advantages of the invention can be seen from the attached patent claims and from the graphic representation and the subsequent description of a preferred embodiment of the invention. In the drawing:

Figure 1 shows a schematic plan view of a printed circuit board having an input circuit under the invention (shown schematically) for the measurement signal from a sensor; and

Figure 2 shows a sectional view of a printed circuit board with a schematic representation of an input circuit.

Figure 1 shows a plan view onto a printed circuit board having a high resistance input circuit 1 for the measurement signal from a glass-based pH-sensor, where one sensor electrode is formed by a glass encapsulation of a measurement cell electrolyte.

The input circuit 1 is located on a first printed circuit board area 2 of a printed circuit board 4, identified in its entirety with the reference numeral 4 and

made of a conventional FR4 material, and it comprises electrical and electronic components, such as an operational amplifier 6, resistances 8 and capacitors. The first printed circuit board area 2, which forms a high-resistance section of the printed circuit board, is separated in the plan view of Figure 1 from the remaining second area 12 of the printed circuit board 4 by a circumferential channel-shaped recess 10.

Figure 2 shows a schematic sectional view of the structure of the printed circuit board 4 with the input circuit, where the illustration cannot be assigned to any particular sectional plane in Figure 1, but is only a schematic representation of the structure, where corresponding parts are given the same reference numeral. So Figure 2 shows a printed circuit board 4 formed from three layers of FR4 material, which is copper-clad on both sides, where partial breaks have been introduced in the outer copper layers 14, 16 during production. The printed circuit board 4 comprises in its interior additional metal layers 18, 19. The first printed circuit board area 2 previously mentioned in connection with Figure 1 is bordered by the circumferential channel-shaped recess 10 and thereby separated from the other second printed circuit board area 12 in the plan view in Figure 1. As can be seen from Figure 2, the channel-shaped recess 10 terminates in the interior of the printed circuit board 4. So no continuous island is formed as under DE 198 01 736 A mentioned initially. The possibility would not be excluded that the sections of the channel-shaped recess 10 could extend through to the other side. However, it is essential that the layer 18, which underlies the first area 2 of the printed circuit board 4, is reached when introducing the channel-shaped recess, for example by routing. This area of the layer 18 forms a fluid and moisture-impermeable barrier layer, so that a moisture-impermeable encapsulation of the first area 2 and of the input circuit located on it is achieved. At least that section 22 of the layer 18 which underlies the first area 2 is moisture-impermeable and forms the barrier layer 20; preferably this is a metallic layer 18. Then either a moisture-impermeable sealing material 24, which is also poured into the channel-shaped recess 10, can be immediately adjacent to this section 22 or the barrier layer 20 respectively and thus form a moisture-impermeable encapsulation, or – as in the situation depicted in Figure 2 – walls 26 on the printed circuit board, which border the channel-shaped recess 10, are furnished with a

moisture-impermeable layer of this type, preferably a metal coating 28 which for its part is contiguous with the barrier layer 20 and is attached continuously to it in a fluid-tight manner along its edges. In this way a moisture-impermeable, preferably metallic, sink is formed which borders the first area 2 on which the input circuit is located. Furthermore, after assembling the components on the printed circuit board 4 (only one component 30 of the input circuit is shown schematically) a moisture-impermeable, epoxy-based sealing material 24 is poured both into the depression formed by the channel-shaped recess 10 as well as over the entire first area 2. It was determined that encapsulation of this type of the input circuit does not allow moisture to reach the input circuit, either from outside or from inside. It is possible to work with conventional printed circuit board materials which can absorb and conduct moisture within the printed circuit board. By providing the moisture-impermeable barrier layer 20 in the form of section 22 of the layer 18, the second area 2 of the printed circuit board 4 carrying the input circuit can be insulated effectively to the inside. No moisture enters the second area 2 and thus does not reach the high-resistance circuit section. To the outside, the sealing material 24 forms a moisture-proof termination. In this way the high-resistance condition existing at the time of production remains intact even under operating conditions.

Incoming or outgoing signals to or from the input circuit are received or transmitted respectively through resistances 32, the pad of one of which is located in the interior of the encapsulated area and the pad of the other of which is located in the outer second area 12 of the printed circuit board. The sealing material surrounds the normally ceramic body of the resistance 32 in such a way that no moisture can penetrate. The contacts for the measurement signal from the pH-sensor can be provided through a Teflon connector 34. Because of the poor adhesion of Teflon to the sealing materials under discussion here, the Teflon housing body of the connector 34 is positioned outside the sealing material 24, where the pads of the connector, however, extend through the sealing material 24.

Attention must be drawn to the fact that the surface area of the printed circuit board, namely the first area 2, on which the input circuit components are to be

installed, is not provided with an additional coating, for example solder resist, in order not to jeopardize the high resistance between the conductor paths.

111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000